ENERGY STAR Connected Thermostats

Stakeholder Working Meeting
Field Savings Metric

March 24, 2017

Attendees

Abigail Daken, EPA
Dan Cronin, EPA
Dan Baldewicz, ICF International, for EPA
Alan Meier, LBNL
Brock Glasgo, Carnegie Mellon
Michael Blasnik, Nest Labs
Jing Li, Carrier
Sunny Amed, Carrier
Dave Mannfeld, Carrier
Brent Huchuck, Ecobee
Michael Siemann, Whisker Labs
Alex Bosenberg, NEMA
Ed Pike, Energy Solutions, for CA IOUs
Ulysses Grundler, Ecofactor
Kurt Mease, Lux Products
John Sartain, Emerson
Diane Jakobs, Rheem
Chris Puranen, Rheem
Brian Rigg, JCI
Theresa Gillette, JCI
Shawn Hern, JCI
Tao Jia, Daikin
Jerry Huson, Bosch Thermotechnologies
Phillip Kelsven, BPA
Ethan Goldman, VEIC
Poormehr Honarmand, Comcast
Jack Callahan

Agenda

- Review of 2017 metric improvement priorities and work plans
- In depth discussion of variable and staged capacity systems

2017 Metric improvement priorities

- During February meeting, identified a variety of possible improvements, and polled attendees about their priority

Topic	First priority (# of people)	Second priority (# of people)	Weighted sum
Weather normalization	1	3	2.5
Modulating equipment	0	6	3
Multi stage equipment	1	4	3
Regional temperature baselines	10	0	10
Multi-thermostat homes	4	3	5.5
Handling missing data	2	1	2.5

Metric improvements meta-questions

- Two meta-questions that may be useful to ask for each of these topics came up at the February meeting

- **Which effects create the largest distortions – are there small studies or easy tests out there to guide us?**

- **How accurate do we need to be for this standard? What inequity, from a policy perspective, is the inaccuracy driving?**

Regional temperature baselines

- Rated as the highest priority
- Has the potential to recognize a wider range of savings strategies
- Meta questions: do we know how big a difference this could make? Definitely has the potential to drive inequities between CT products.
- A path to address this has been identified
  - Carnegie Mellon University researchers are interested in this as a research problem
  - Proposed as a two year project
  - Regular updates and discussions of the work will occur in these metrics meetings, but the bulk of the work will happen outside this group

Homes with multiple thermostats

- Rated as the second priority; closely related to zoning
- Meta questions: Many homes with CTs have multiples (1/3?); some systems inherently zoned; but not clear how inappropriate the current metric will be
- No clear path to address this has been identified
  - Focus the April metrics meeting on this topic?
  - If so, would be helpful to have some better definition of the problem (e.g. includes fully zoned?), and possible paths to gauge its urgency and address it, identified for the April meeting
  - Are a subset of stakeholders interested in working on this topic, to make progress outside of these monthly meetings? Blasnik, Meier, Rigg, Goldman, Jia, Huchuk

Multi stage and modulating equipment

- Two topics tied for third priority
- Meta questions: Clear that metric as it currently exists is not usable for these systems; also clearly drives inequity, by limiting participation of OEM CTs designed for modulating equipment
- Not a lot of stakeholders indicated they could put time and/or resources into this topic, however outreach to HVAC OEMs has been fruitful
- These topics are the focus of this meeting
- Is this one topic or two?
  - Last meeting there was some discussion that separate strategies may be needed for the two
- To be continued later in this meeting…

Additional metric improvements

- Not a lot of interest in weather normalization.
  - Not clear how much lack or normalization matters or whether it produces any inequity.
  - Simple ideas to check how much difference it makes: Simulation, check consistency of metric scores year to year
- Additional thought to handling missing data was also a fairly low priority
  - A couple people felt strongly about this topic: you are encouraged to bring proposals to the group for consideration

Framing questions for multi stage and modulating equipment

- What data are available? To both proprietary and 3rd party thermostats?
- How do we separate savings due to the thermostat from savings due to the equipment, either through zoning or through efficient operation?
- Should we consider multi stage and modulating equipment together, or separately?
- Do we need a different approach for AC and heat pumps than for furnaces and boilers?

Framing questions discussion

- Staged: two (or maybe more) stages of cooling/heating capacity. May be more than one compressor, or a single compressor. Also staged capacity burners for boilers and furnaces. 2 and 3 stage CAC, Heat pumps, and furnaces very popular. 5 stage central heat pumps available as well, also popular, and for boilers.
- Modulating: fairly continuous capacity variation from a maximum capacity to a minimum capacity, with the ability to adjust delivered heating and cooling to the load.
- Staged equipment with 5 or more stages will practically be very similar to modulating – several people recommend considering anything with more than 3 stages to be modulating. Pointed out that 2 and 3 stage units are basically adjusting for sizing errors and then operating as single capacity; not true of 5 stage which can truly match load and not cycle on and off much
- Complication that some more capable equipment will be matched with a third party thermostat, in which case it will operate more simply. Many different options for whether staging/modulating is controlled by the equipment when the thermostat is less capable. (e.g. two stage furnace controlled with a single wire from the thermostat)
- Field installations may not match design intention: claim that the evaluation should be based on design intention

Framing questions discussion

- We allow heat pumps in, where staging (back up heat) has a far larger impact on energy use than for multi stage systems – why is this different?
- Difference in control strategies vendor to vendor? Not really – always use low stage(s) as much as possible
- For modulating equipment, very little evidence of efficiency difference between capacities, whereas for heat pumps (compared to strip heat) there is a huge difference in efficiency.
  - Request for research showing actual savings from modulating systems with ducts outside conditioned space? Yes, conduction losses can reduce efficiency at lower capacities (ducts are warm longer, more total energy lost), but counteracting that, if the system is oversized for the ducts, there will be a fan efficiency advantage to the lower speed, and in some cases you won't get the airflow you need at higher speed anyway.
  - Also a clear efficiency advantage for ductless, and for modulating condensing boilers
- Zero in on control strategies that maximizes use of minimum capacity: note that set back may not always be an energy saving strategy
- Thermostat can provide savings through encouraging more energy efficient settings, and may also be able to provide savings through maximizing use of minimum capacity
- Not easy to separate savings from equipment and from the thermostat

Framing questions discussion

- Different approach for AC/HP than for furnaces and boilers? CONSENSUS: NO
  - Makes it more complicated to separate thermostat savings from equipment savings?
  - Not always able to determine which equipment is connected through wiring, for conventional thermostats. Newer CTs may be limited by a need for backward compatibility, or may have richer functionality. Realistically may not be able to separate.
  - Appliance shouldn't matter, but load and timing to satisfy load (more adaptability) may be an advantage
- Thinking about data available, increasingly the system itself may have a proxy for energy used (better proxy than run time). Perhaps that is a distinction between the systems.
- Rate of rise could be used to differentiate the types of systems connected. Duct losses would also show up in rate of rise. No broad enthusiasm for this approach at the moment.

Framing questions discussion

- What data is available from the thermostat?
  - Currently: indoor temperature, set temperature, run time of all equipment, whether there is a reversing valve wired, presence of heating equipment & cooling equipment, resistance heat run time
  - Indoor temperature and set temperature available for any system
  - If we are not relying on run time, what data do we have to rely on?
    - Weighted run time: need to know capacity at each minute of run time. Proprietary thermostats have this data. Thermostats that do not have a serial bus do not have this data.
    - Could have input at installation of stage capacity. Use a default? 20% would be conservative. Two stage furnaces and A/Cs fairly consistent in terms of relative capacity… some disagreement on this point. CONSENSUS: For two stage furnaces, A/C, and heat pump (for compressor heating), a default value for relative capacities of the stages would work. Not relevant to boilers.

Framing questions discussion

- Which systems have estimated actual energy use?
  - Actual energy use not required – normalized to maximum is fine.
  - Some but not all proprietary controllers have this data, derived from the control system drive signals to the compressor(s) and fan(s). All have the control system drive signals themselves, which give an estimate of capacity, and it's not clear that translating that to estimated energy use gives you better information for a metric. What about other energy use (e.g. crankcase heater) that could be inferred from system control signals?
  - This data isn't available to 3rd party controllers or any 24 V controllers
  - Some modulating equipment works just fine with 24V thermostats; in most cases, optimum performance is achieved with proprietary thermostats, particularly will give you more non-energy benefits: comfort, noise, etc.
  - For systems sold with proprietary thermostats, does an ENERGY STAR label influence purchase? In what circumstances will a consumer be choosing an after-market thermostat? Some consumers will forego a proprietary thermostat in favor of an ENEREGY STAR labeled thermostat that will not deliver the efficiency they expect in that circumstance, nor the comfort.

Multi stage and modulating equipment ideas

- SDH metric
- Capacity-weighted run time (especially for 2 stage)
- Correlate estimated system energy use with indoor-outdoor temperature difference
- Persistent question of whether you can recognize thermostat savings separate from HVAC equipment savings for the most sophisticated systems

Contacts for various work streams

- **Regional temperature baselines**:
  Brock Glasgo, 513-519-1008, bglasgo@Andrew.cmu.edu
- **Multi thermostat homes/zoning**:
  Alan Meier, 510-486-4740, akmeier@lbl.gov
  Dan Baldewicz, 518-452-6426, dan.baldewicz@icf.com
- **Staged/variable capacity systems:**
  Abi Daken, 202-343-9375, daken.abigail@epa.gov
- **Incomplete data:**
  Any volunteers to be a central point of contact?

- Everything else, including the specification:
  Abi Daken, 202-343-9375, daken.abigail@epa.gov or
  Dan Baldewicz, 518-452-6426, dan.baldewicz@icf.com

Recap: ENERGY STAR Connected Thermostats

- Connected Thermostats Version 1.0 is available for certification:
  - Eligibility Criteria for Version 1.0.
  - Method to Demonstrate Field Savings.
  - Random Number Seeds for Savings Method.

Recap: Software

- Current Software is Thermostat Module V1.1.1:
  - Packages on PyPI: https://pypi.python.org/pypi/thermostat/1.1.1
    - Pip install thermostat
  - Source Code on GitHub: https://github.com/EPAENERGYSTAR/epathermostat
  - Documentation on ReadTheDocs: http://epathermostat.readthedocs.io/en/latest/